FORM PTO-1390 (REV. 11-2000) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

# TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY 'S DOCKET NUMBER: 2165JB.45631

U S APPLICATION NO (If known, see 37 CFR 1 5): Unknown 09/936917

| INTERNATIONAL APPLICATION NO. | INTERNATIONAL FILING DATE | PRIORITY DATE CLAIMED |
|---|---|---|
| PCT/GB00/01129 | March 24, 2000 | March 31, 1999 |

TITLE OF INVENTION: Sheet Material Processing

APPLICANT(S) FOR DO/EO/US: John Anthony Sullivan

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [ ] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [X] The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] is attached hereto (required only if not communicated by the International Bureau).
   b. [X] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. [ ] is attached hereto.
   b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [X] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b. [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [X] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. [X] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

**Items 11 to 20 below concern document(s) or information included:**

11. [X] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [X] A FIRST preliminary amendment.
14. [ ] A SECOND or SUBSEQUENT preliminary amendment.
15. [ ] A substitute specification.
16. [X] A change of power of attorney and/or address letter.
17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. [ ] A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. [ ] A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. [X] Other items or information:
    Small Entity Statement

| U.S. APPLICATION NO (if known, see 37 CFR 1.5) | INTERNATIONAL APPLICATION NO | ATTORNEY'S DOCKET NUMBER |
|---|---|---|
| Unknown 09/936917 | PCT/GB00/01129 | 2165JB.45631 |

| 21. [X] The following fees are submitted: | CALCULATIONS PTO USE ONLY | |
|---|---|---|
| **BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):** | | |
| Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO ..... **$1000.00** | | |
| International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ..... **$860.00** | | |
| International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... **$710.00** | | |
| International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... **$690.00** | | |
| International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) ..... **$100.00** | | |
| **ENTER APPROPRIATE BASIC FEE AMOUNT =** | $ 860.00 | |
| Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)). | $ | |

| CLAIMS | NUMBER FILED | NUMBER EXTRA | RATE | | |
|---|---|---|---|---|---|
| Total claims | 52 - 20 = | 32 | x **$18.00** | $ 576.00 | |
| Independent claims | 6 - 3 = | 3 | x **$80.00** | $ 240.00 | |
| MULTIPLE DEPENDENT CLAIM(S) (if applicable) | | | + **$270.00** | $ | |
| **TOTAL OF ABOVE CALCULATIONS =** | | | | $ 1676.00 | |
| [X] Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. | | | + | $ 838.00 | |
| **SUBTOTAL =** | | | | $ 838.00 | |
| Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). | | | | $ | |
| **TOTAL NATIONAL FEE =** | | | | $ 838.00 | |
| Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property + | | | | $ | |
| **TOTAL FEES ENCLOSED =** | | | | $ 838.00 | |
| | | | | **Amount to be refunded:** | $ |
| | | | | **charged:** | $ |

a. [X] A check in the amount of $ 838.00 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 50-0259 . A duplicate copy of this sheet is enclosed.

(2165JB.45631)

d. [ ] Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.**

SEND ALL CORRESPONDENCE TO:

James E. Bradley
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Houston, Texas 77208-1389

James E. Bradley
SIGNATURE

James E. Bradley
NAME

27,536
REGISTRATION NUMBER

Attorney Docket No.
2165JB.45631

| | |
|---|---|
| Applicant or Patentee: | John Anthony SULLIVAN |
| International Appl. No.: | PCT/GB00/01129 |
| Filed: | 24 March 2000 |
| For: | Sheet Material Processing |

**VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) and 1.27(b)) INDEPENDENT INVENTOR**

As a below named inventor, I hereby declare that I qualify as an independent inventor as defined in 37 CFR 1.9 (c) for purposes of paying reduced fees under section 41 (a) and (b) of Title 35, United States Code, to the Patent and Trademark Office with regard to the invention entitled described in:

[ ] the specification filed herewith
[X] International application no.PCT/GB00/01129
[X] filed 24 March 2000

I have not assigned, granted, conveyed or licensed except as shown in the attachment hereto and am under no obligation under contract or law to assign, grant, convey or license, any rights in the invention to any person who could not be classified as an independent inventor under 37 CFR 1.9 (c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 CFR 1.9 (d) or a nonprofit organization under 37 CFR 1.9 (e).

Each person, concern or organization to which I have assigned, granted, conveyed, or licensed or am under an obligation under contract or law to assign, grant, convey, or license any rights in the invention is listed below:

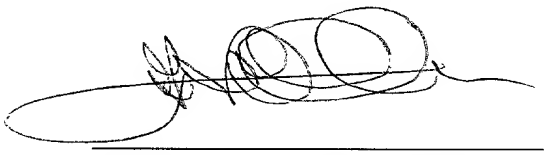
[X] no such person, concern, or organization
[ ] persons, concerns or organizations listed below*

FULL NAME:
ADDRESS:

[ ] Individual[ ] Small Business Concern [ ] Nonprofit Organization

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28 (b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.



**John Anthony SULLIVAN**

8th August 2001

**Date**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | | |
|---|---|---|
| IN RE APPLICATION OF: | § | |
| **John Anthony Sullivan** | § | DOCKET NO.:**2165JB.45631** |
| | § | |
| SERIAL NO.: **Unknown** | § | GROUP NO.: **Unknown** |
| | § | |
| FILED: **Herewith** | § | |
| | § | |
| TITLE: **Sheet Material Processing** | § | EXAMINER: **Unknown** |

## PRELIMINARY AMENDMENT

Honorable Commissioner of
Patents and Trademarks
Washington, D.C. 20231

Sir:

Please amend the above-identified application as follows:

Cancel claims 1 - 51.
Add new claims 52 - 102 as set forth below.

52. Apparatus for processing sheet material comprising;

a set of rotatable rolls provided with one or more sheet-processing tools for engagement with the sheet material in the nip zone between the roll set;

a first drive for rotating the roll set;

a second drive upstream of the nip zone for effecting feed of the sheet material; and

means operable to co-ordinate operation of the second drive with rotation of the roll set in such a way that sheet feed through the nip zone is effected for part of the time by the roll set and for part of the time by the second drive, the second drive imparting feed to the sheet material through drive transmitting means which freewheel while in engagement with the roll driven sheet.

53. Apparatus for processing sheet material comprising;

a set of rotatable rolls provided with one or more sheet-processing tools for engagement with the sheet material in the nip zone between the roll set;

a first drive for rotating the roll set;

a second drive upstream of the nip zone for effecting feed of the sheet material; and

means operable to co-ordinate operation of the second drive with rotation of the roll set in such a way that sheet feed through the nip zone is effected for part of the time by the roll set and for part of the time by the second drive.

54. Apparatus as claimed in Claim 52 in which the feed of sheet material through the nip zone is effected by the roll set at least while there is tool-sheet engagement.

55. Apparatus as claimed in Claim 52 in which feed of sheet material through the nip zone is effected by the second drive at least for part (preferably a major part) of the time that there is no tool-sheet engagement.

56. Apparatus as claimed in Claim 52 in which the roll set is provided with two or more circumferentially spaced sheet-processing tools.

57. Apparatus as claimed in Claim 56 in which the roll set is provided with a traction section trailing one of the tools for imparting feed motion to the sheet material subsequent to disengagement between said one tool and the sheet.

58. Apparatus as claimed in Claim 52 in which the second drive is a variable speed drive operable to vary the speed profile of sheet material feed through the nip zone.

59. Apparatus as claimed in Claim 52 including means for braking or damping freewheeling of said drive transmitting means so that freewheeling is arrested substantially immediately upon disengagement of the sheet from the drive transmitting means.

60. Apparatus as claimed in Claim 52 in which the drive transmitting means comprises rollers which engage the sheet material.

61. Apparatus as claimed in Claim 52 in which the drive transmitting means includes one or more endless conveyor belts which engage the sheet material.

62. Apparatus as claimed in Claim 52 in which, during roll driven sheet material feed, the second drive is arrested or operates at a reduced drive speed compared with the roll drive speed.

63. Apparatus as claimed in Claim 52 in which, during roll driven sheet material feed, the second drive is arrested or operates at a reduced drive speed compared with the roll drive speed and in which said drive transmitting means operates automatically in freewheel mode when engaged with sheet material being fed at a speed exceeding that of the second drive.

64. Apparatus as claimed in Claim 52 in which, immediately prior to transfer of sheet material feed from the second drive to the roll set or *vice versa*, the second drive is programmed to run at a speed which is reduced compared with the roll speed.

65. Apparatus as claimed in Claim 52 in which, during the interval leading up to transfer of sheet material feed from the second drive to the roll set or *vice versa*, the second drive operates in a mode in which its speed exceeds the roll speed and is then adjusted to a lower speed.

66. Apparatus as claimed in Claim 65 in which said lower speed is less than the roll speed.

67. Apparatus as claimed in Claim 52 in which the co-ordinating means is programmable in dependence upon the configuration of tool operations to be performed on the sheet.

68. Apparatus as claimed in Claim 52 in which the sheet material is fed to the roll set as discrete blanks.

69. Apparatus as claimed in Claim 52 in which the sheet material is fed to the roll set as a continuous web of material.

70. Apparatus as claimed in Claim 52 in which the second drive comprises a feed table having a gate and upon which the sheets may be stacked against the gate which allows only the lowermost sheet to pass therebeneath, a bed of rollers within the surface of the table which may be rotatably driven to advance the lowermost sheet beneath the gate to the take-up mechanism, means to allow the rollers to free-wheel once the lowermost sheet is being advanced thereover by said take-up mechanism, and means for restraining freewheeling roller feed of the next lowermost sheet after the sheet being fed has passed under the gate.

71. Apparatus as claimed in Claim 52 in which the second drive comprises a feed table having a gate and upon which the sheets may be stacked against the gate which allows only the lowermost sheet to pass therebeneath, a bed of rollers within the surface of the table which may be rotatably driven to advance the lowermost sheet beneath the gate to the take-up mechanism, means to allow the rollers to free-wheel once the lowermost sheet is being advanced thereover by said take-up mechanism, and means for restraining freewheeling roller feed of the next lowermost sheet after the sheet being fed has cleared the rollers.

72. Apparatus as claimed in Claim 52 in which the second drive comprises a feed surface having a gate and upon which the sheets may be stacked against the gate which allows only the lowermost sheet to pass therebeneath, conveyor means associated with the feed surface for advancing the lowermost sheet beneath the gate to the take-up mechanism, means to allow the conveyor means to

free-wheel once the lowermost sheet is being advanced thereover by said take-up mechanism, and means for restraining freewheeling feed of the next lowermost sheet after the sheet being fed has cleared the conveyor means.

73. Apparatus as claimed in Claim 72 in which the conveyor means comprises roller means which directly engage with the lowermost sheet.

74. Apparatus as claimed in Claim 72 in which the conveyor means comprises roller means which contact the lowermost sheet indirectly through one or more conveyor belts entrained around the roller means.

75. Apparatus as claimed in Claim 70 in which the restraining means comprises brake means acting on the rollers or conveyor means.

76. Apparatus as claimed in Claim 70 in which the restraining means comprises vacuum suction means located upstream of the rollers or conveyor means to hold the next lowermost sheet against the action of the freewheeling rollers after the sheet being fed has passed under the gate.

77. Apparatus according to Claim 70 in which the take-up mechanism comprises a tool-carrying roll-set.

78. Apparatus according to Claim 70 in which the rollers or conveyor means are fitted with sprag clutches and advance the sheet being fed at substantially the same speed as, or a slower speed than that of, the take-up mechanism.

79. Apparatus according to Claim 70 in which the rollers or conveyor means are driven by a servo electric motor which alternately drives the rollers or conveyor means forwardly and stops, the timing of the motor being controlled by the processing machinery.

80. Apparatus according to Claim 70 wherein vacuum suction is applied from beneath the rollers or conveyor means to pull the lowermost sheet downwardly against the rollers.

81. Apparatus according to Claim 70 wherein the rollers are rotatably interconnected by timing drive belt means, one of which rollers is driven by a further timing drive belt.

82. Apparatus according to Claim 81 wherein said further drive belt is toothed.

83. Apparatus for feeding sheet material sequentially on demand to take-up mechanism of sheet processing machinery, said apparatus comprising a feed table having a gate and upon which sheets may be stacked against the gate which allows only the lowermost sheet to pass therebeneath, drive transmitting means driven by a servo-motor to advance the lowermost sheet beneath the gate to the take-up mechanism, a sensing means between the gate and the take-up mechanism to detect the passage of a datum position of the sheet, a microprocessor which receives data indicating the position of the take-up mechanism and from the sensing means and programmed to control the servo-motor to ensure that the sheet presents itself to the take-up mechanism at the correct instant.

84. Apparatus for feeding sheet material sequentially on demand to take-up mechanism of sheet processing machinery, said apparatus comprising a servo-drive motor, means for transmitting drive from the servo-drive motor to the sheet material to advance the sheet material to the take-up mechanism, sensing means for detecting the passage of a datum position of the sheet material as the latter advances towards the take-up mechanism, and a microprocessor which receives data indicating the position of the take-up mechanism and from the sensing means and programmed to control the servo-drive motor to secure registration between the sheet material and the take-up mechanism, the drive transmitting means being operable automatically in a freewheel mode while in engagement with sheet material travelling at a speed greater than the speed of the servo-drive motor.

85. Apparatus according to claim 83 wherein the microprocessor is programmed to ensure that the leading edge of the sheet presents itself to the take-up mechanism at a desired speed.

86. Apparatus according to claim 85 wherein the desired speed is slightly less than the speed at which the take-up mechanism forwards the sheet.

87. Apparatus according to claim 85 wherein the desired speed is zero.

88. Apparatus according to Claim 83 wherein the take-up mechanism comprises a pair of take-up rolls.

89. Apparatus according to Claim 83 wherein the take-up mechanism comprises gripper bars.

90. Apparatus according to Claim 52 wherein the means driven by the second drive or the servo-motor comprises a bed of rollers within the surface of the table which are rotatably driven to advance the lowermost sheet beneath the gate to the take-up mechanism when forward drive to the rollers is arrested and means to allow the rollers to free-wheel once the lowermost sheet is being advanced thereover by the roll set or take-up mechanism.

91. A method of treating sheet material by passage through the nip between a set of rotatable rolls provided with a least one sheet treatment tool, comprising:
driving the sheet material through the nip for part of the time by means of the rolls and for part of the time by a separate servo-controlled drive which acts on the sheet material at a location upstream of the nip, the servo-controlled drive being transmitted to the sheet through roller means or conveyor belt means capable of freewheeling while in contact with the roll set-driven sheet material.

92. A method of treating sheet material by passage through the nip between a set of rotatable rolls provided with a least one sheet treatment tool, comprising:
driving the sheet material through the nip for part of the time by means of the rolls and for part of the time by a separate servo-controlled drive which acts on the sheet material at a location upstream of the nip.

93. A method as claimed in Claim 91 including supplying the sheet material to the nip in the form of discrete sheets.

94. A method as claimed in Claim 91 including supplying the sheet material to the nip in the form of a continuous web.

95. A method as claimed in Claim 94 in which the continuous web is severed into discrete sheets by the rolls.

96. A method as claimed in Claim 93 in which the length of the discrete sheets exceeds the circumference of the tool-carrying roll.

97. A method as claimed in Claim 91 in which, between successive tool-sheet operations on a given sheet or section of sheet material, the servo-controlled drive feeds a section of sheet through the nip of a length which differs from the circumferential spacing on the roll between the tool(s) effecting such operations.

98. A method as claimed in Claim 91 including applying a braking force to the freewheeling roller means or conveyor belt means to prevent over run thereof.

99. A method as claimed in Claim 91 including sensing the sheet position by detection of a datum position on the sheet and controlling sheet feed by the servo-controlled drive to secure at least initial registration between the sheet and the roll set tooling.

100. A method as claimed in Claim 91 including sensing the sheet position by detection of a plurality of lengthwise spaced datum positions on the sheet and controlling sheet feed by the servo-controlled drive to secure and maintain registration between the sheet and the roll set tooling.

101. A method as claimed in Claim 91 including feeding a terminal trailing section of the sheet through the nip by means of a non-tool-carrying section of the roll set.

102. Sheet treated by the method claimed in Claim 91.

## REMARKS

Applicant submits that claims 52 - 102 are in condition for allowance. If there are any outstanding issues, Applicant would appreciate a telephone call from Examiner.

A check in the amount of $838.00 is enclosed to cover the filing fee for the claims. Please charge any additional fees to deposit account no. 50-0259 (2165JB.45631).

Respectfully submitted,

James E. Bradley
Reg. No. 27,536
Attorney for Applicant

Date: Sept. 19, 2001

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# SHEET MATERIAL PROCESSING

This invention concerns apparatus use in the processing of sheet material, particularly, though by no means exclusively, of corrugated board or card as used in the box and carton making industries.

One aspect of the present invention is concerned with the control of sheet material feed upstream of, and through, the nip between rotating rolls provided with one or more sheet-treatment tooling sets for effecting cutting, printing, creasing and/or scoring etc of the sheet material. In conventional sheet processing machinery, sheet material feed through the nip is imparted by the rotating rolls via tool-sheet engagement and, when the tooling is disengaged from the sheet, via traction belts or the like provided on the rolls. This necessarily imposes limitations on the variety of blank sizes that can be catered for.

According to one aspect of the present invention there is provided apparatus for processing sheet material comprising;
a set of rotatable rolls provided with one or more sheet-processing tools for engagement with the sheet material in the nip zone between the roll set;
a first drive for rotating the roll set;
a second drive upstream of the nip zone for effecting feed of the sheet material; and
means operable to co-ordinate operation of the second drive with rotation of the roll set in such a way that sheet feed through the nip zone is effected in part by the roll set and in part by the second drive.

Various features of this aspect of the invention including a related method are the subject of claims appended to this specification.

Another aspect of the invention is concerned with the feed of sheet material to processing machinery in which stacked sheets are placed on a feed table against a gate which allows only the lowermost sheet to pass therebeneath to be taken into the nip of take-up rolls. In known equipment, this may be effected under the action of a reciprocating vacuum suction cup, feed rollers or a kicker mechanism. Such feeding arrangements must be controlled with great precision and even then misfeeds are a not uncommon experience. One solution to these problems is proposed in my British Patent No. 2 274 276, but this involves reciprocating movement of the entire roller bed, which is not energy efficient and places certain restrictions on sheet size.

According to a second aspect of the present invention there is provided for apparatus for feeding sheet material sequentially on demand to take up mechanism of sheet processing machinery, said apparatus comprising a feed surface having a gate and upon which the sheets may be stacked against the gate which allows only the lowermost sheet to pass therebeneath, conveyor means (such as a bed of rollers or a conveyor belt) associated with the feed surface for advancing the lowermost sheet beneath the gate to the take-up mechanism, means to allow the conveyor means to free-wheel once the lowermost sheet is being advanced thereover by said take-up mechanism, and means for restraining freewheeling feed of the next lowermost sheet after the sheet being fed has cleared the conveyor means.

In one embodiment, such freewheeling feed by the conveyor means may be restrained by some form of braking means acting on the next lowermost sheet, e.g. vacuum suction means behind the rollers to hold the next lowermost sheet against the action of the free-wheeling rollers after the sheet being fed has passed under the gate.

In another embodiment, such freewheeling feed by the conveyor means may be restrained by braking means acting on the conveyor means.

The take-up mechanism may comprise take-up rolls.

The conveyor means may comprise rollers fitted with sprag clutches and may advance the sheet being fed at substantially the same speed as or, more preferably, a slower speed than, that of the take-up mechanism.

Vacuum suction may be applied from beneath the conveyor means to pull the lowermost sheet downwardly thereagainst.

A further aspect of the invention is concerned with ensuring that feed of the sheet material is in proper registry with the sheet-treatment machinery.

To this end prior known sheet feeding apparatus has relied upon the leading edge of each sheet being at a defined position at the commencement of feed. Many factors, including premature movement of a sheet by continuing rotation of feed rollers after the previously fed sheet has cleared them, mechanical tolerances, improper stacking of the sheets on the feed table, sheet quality and even atmospheric conditions can cause the leading edge of a sheet to be displaced from the expected defined position at the commencement of feed.

According to a third aspect of the present invention there is provided apparatus for feeding sheet material sequentially on demand to take-up mechanism of sheet processing machinery, said apparatus comprising a feed table having a gate and upon which sheets may be stacked against the gate which allows only the lowermost sheet to pass therebeneath, means driven by a servo-motor to advance the lowermost sheet beneath the gate to the take-up mechanism, a sensing means between the gate and the take-up mechanism to detect the passage of a datum position of the sheet, a microprocessor which receives data indicating the position of the take-up mechanism

and from the sensing means and programmed to control the servo-motor to ensure that the sheet presents itself to the take-up mechanism at the correct instant.

The datum on the sheet may be constituted by the leading edge of the sheet or some other suitably positioned mark on the sheet, e.g. printing previously applied to the sheet, a cut-out in the sheet or a print registration mark on the sheet. Prior to sheet treatment involving cutting and/or creasing for instance, it is common practice to apply printing to the sheet for product identification and/or advertising purposes and the subsequent sheet treatment has to be accurately registered with such printing. If the location of the printing is accurately positioned with the leading edge of the sheet and if the leading edge of the sheet has not been damaged in any way, then the leading edge may be used as the datum. However, if print position in relation to the leading edge is not consistent and/or if there is a possibility of the leading edge being damaged, then use of the printing itself as the datum source is to be preferred so that proper registry between the machinery tooling and the printed areas can be secured. Where the datum is derived from pre-applied printing on the sheet, it may be constituted for example by the a leading extremity of a selected part of the printed area.

The microprocessor may also be programmed to ensure that the sheet, or at least the leading edge thereof, presents itself to the take-up mechanism at a desired speed.

The desired speed may be substantially the same as but preferably is slightly less than the speed at which the take-up mechanism forwards the sheet. The desired speed may be substantially zero.

In this aspect of the invention, the take-up mechanism may comprise a pair of take-up rolls or gripper bars and the means driven by the servo-motor may comprise

a bed of rollers within the surface of the table which are rotatably driven to advance the lowermost sheet beneath the gate to the take-up mechanism and means to allow the rollers to free-wheel once the lowermost sheet is being advanced thereover by the take-up mechanism.

According to yet another aspect of the present invention there is provided apparatus for feeding sheet material sequentially on demand to take-up mechanism of sheet processing machinery, said apparatus comprising a servo-drive motor, means for transmitting drive from the servo-drive motor to the sheet material to advance the sheet material to the take-up mechanism, sensing means for detecting the passage of a datum position of the sheet material as the latter advances towards the take-up mechanism, and a microprocessor which receives data indicating the position of the take-up mechanism and from the sensing means and programmed to control the servo-drive motor to secure registration between the sheet material and the take-up mechanism, the drive transmitting means being operable automatically in a freewheel mode while in engagement with sheet material travelling at a speed greater than the speed of the servo-drive motor.

These and various other aspects and features of the invention will be further apparent from the following description with reference to the figures of the accompanying drawings, in which:

Figure 1 shows a side elevation of a first form of feed apparatus;

Figure 2 shows a cross-section through the apparatus on the line II-II of Figure 1;

Figure 3 shows a side elevation of a second form of feed apparatus;

Figure 4 is a view similar to that of Figure 1 showing a modified embodiment having a servo-drive for controlling positioning of the sheets;

Figure 5 is a diagrammatic view of another embodiment of the invention in which sheet feed is shared between a servo-drive of the form illustrated in Figure 4 and the tool-carrying rolls for processsing the sheet;

Figure 6 is a schematic view of a longer sheet than that shown in Figure 5; and

Figure 7 is a schematic view of another embodiment of drive transmission for controlling advance of the sheet material towards and through the nip of the tool-carrying rolls.

Referring now to Figures 1 and 2 it will be seen that the apparatus comprises a feed table 10 upon which a stack of sheets S may be placed against a gate 11 beneath which only the lowermost sheet in the stack may pass. Successive sheets are advanced beneath the gate 11 into the nip of take-up rolls 12 by a bed 13 of rollers 14 within the surface of the table. The take-up rolls 12 comprise an upper roll provided with tooling for appropriate treatment of the board, e.g. die cutting, slotting, creasing etc., and a lower roll which is also driven and may be provided with a layer of resiliently deformable material such as polyurethane, or contra tooling to the other roll, for engagement with the sheets as they travel through the nip between the rolls.

The rollers 14 are mounted within a chamber 15 to which vacuum suction is applied to pull the lowermost sheet downwardly thereagainst. The rollers 14 advance the lowermost sheet by being rotatably driven as indicated by the arrows X at a speed equal to or less than the speed of the take-up rolls 12. Once the advance of sheet is under the control of the rolls 12, the rollers 14 by virtue of having sprag clutches between their inner peripheries and their drive shafts 16 are arranged to free-wheel if the speed imparted to the sheet by the rolls exceeds that of the rollers 14. At this stage, the drive to the rollers 14 may be reduced or arrested altogether according to circumstances. Under these conditions, the rollers 14 simply rotate by virtue of their contact with the sheet material as driven by the roll set 12.

At least during this free-wheeling stage forward drive to the rollers 14 may be arrested and a vacuum chamber 30 behind the rollers 14 is exhausted to hold the next lowermost sheet in a fixed position against the action of the free-wheeling rollers after the sheet being fed has passed under the gate 11 to leave an opening through which the next sheet could otherwise prematurely pass. The chamber 30 can be exhausted continuously or cyclically.

The drive shafts 16 are rotatably interconnected by timing drive belts 17 and one shaft is driven by a timing belt 18 itself driven intermittently in a forward direction only by a servo-electric motor 21 which may stop whilst a sheet is being advanced by the take-up rolls 12 and which operates at a timed sequence demanded by the processing machinery.

In Figure 2, the rollers 14 associated with each drive shaft 16 are separated by spacing portions 14a which may be rotatably fast with the rollers. Adjacent sets of rollers staggered; however, in a modification the rollers in

adjacent sets (and the spacing portions between them) may be aligned rather than staggered.

The arrangement of Figure 3 is generally similar, like parts being indicated by like reference numerals. In this embodiment, however, the timing belt 18 is driven by a timing belt 19 reciprocated by an arm 20 operating in time with the processing machinery. Thus the shafts 16 of the rollers 14 are driven in reverse direction during the time that the rollers 14 are free-wheeling. Drive mechanisms other than those shown in Figures 1 to 3 are possible, such as from a reciprocating cam imitating the movement of the arm 20 of Figure 3.

Referring back to Figure 1, the restraint provided by the vacuum chamber 30 to prevent misfeed of the next lowermost sheet may be supplemented by brake means for damping rotation of rollers 14 so that once the sheet being fed has clears each set of freewheeling rollers, their rotation is rapidly arrested to prevent any premature advance of the next lowermost sheet in the stack. The brake means 40 may comprise any suitable mechanism to arrest the rollers once they are no longer driven by their engagement with the sheet being fed. For instance, the brake means 40 may comprise friction pads or more elaborate mechanically, electrically or pneumatically operable means for resisting rotation of the rollers 14. In one embodiment of the invention, the brake means may be arranged to constantly bear against the rollers or a component which rotates with the rollers when the latter are driven or when they freewheel. In this instance, the contacting surfaces may be provided with material such as a PTFE which has sufficiently low friction to reduce wear while affording sufficient braking to prevent freewheeling once the rollers when this could otherwise affect accurate positioning of the blanks. More specifically, after the departing sheet has cleared the rollers 14, the latter are required to be substantially static with respect to the next sheet to be fed so that

that sheet is not advanced by an indeterminate amount (thereby causing misregistration) as could otherwise happen if the rollers 14 are allowed to over run upon disengagement with the previously fed sheet. The rollers 14 remain static until driven by the servomotor 21 when feed of the next sheet is required.

In one implementation of the braking means, the roller arrangement of Figure 2 is modified in the manner previously described where the rollers 14 and the spacing portions 14a are aligned instead of being staggered, and the braking means comprises one or more arms (not illustrated in Figure 2) which each bridge and constantly bear against a respective set of aligned spacing portions 14a to arrest freewheeling thereof as soon as the rollers 14 are no longer driven by the sheet material.

In a further modification, the vacuum chamber 30 may be dispensed with altogether and the necessary restraint to prevent misfeed of the next lowermost sheet by the freewheeling rollers may be provided solely by damping the freewheeling rollers 14, e.g. by means of the brake means 40.

In the embodiments thus far described, misfeed through overrun of the freewheeling rollers is managed by braking the rollers and/or by braking the next lowermost sheet to be fed from the stack. Figure 4 shows another approach which can be used instead of, or together with, sheet or roller braking as described above. Those parts in Figure 4 having counterparts in Figures 1 and 2 are depicted by the same reference numerals and, insofar as they function in the same way as in the embodiment of Figures 1 and 2, will not be described in detail below.

In the embodiment of Figure 4, the drive to the shafts 16 and hence the rollers 14 is provided by a servo-electric motor 21 which is operable to drive the

rollers to effect forward feed of the sheets, one by one, to the rolls 12 but stops whilst a sheet is being advanced by the rolls 12, operation of the motor 21 being in a timed sequence demanded by the processing machinery. The servo-motor 21 is controlled by a microprocessor 50 which receives data from a pulsed shaft encoder 31 indicating the rotational position of the take-up rolls 12 and also from a sensing means comprising for example a high speed fibre optic sensor 32 located between the gate 11 and take-up rolls 12.

The sensor 32 is arranged to detect passage of a datum on the sheet being fed, e.g. the leading edge of the sheet, a cut-out or a preselected printed mark on the sheet. Where the sensor detects a preselected printed mark, this may be specifically provided for the purpose during a preceding step of the sheet treatment process, e.g. on a section of the sheet which is to removed during die cutting, or it may be constituted by a specific sensor-identifiable location of a pre-printed area, e.g. an image or such like, on the sheet.

The microprocessor 50 is programmed to control the servo-motor 21 to ensure that the sheet, e.g. the leading edge of the sheet, presents itself at the nip between the rolls 12 at precisely the correct instant and at a desired speed. It will be understood that the exact position of the leading edge or other datum of any sheet at the commencement of feed is immaterial since any variation is detected by the sensor and microprocessor 50 and can be compensated for by appropriate control of the servo-drive by the microprocessor to effect registry of the tooling on roll set 12 with the desired position on the blank..

Although in the embodiment of Figure 4, misfeed of the lowermost sheet can be compensated for by the sensor and servo-drive arrangement, the vacuum chamber 30 (not shown in Figure 4) and/or the brake means 40 of the embodiment

of Figures 1 and 2 may be incorporated to enhance control of sheet feed, thereby reducing the amount of correction which might otherwise be required by the microprocessor and servo-drive.

The sensor and servo-drive control arrangement of Figure 4 may also be used in conjunction with a take-up mechanism in the form of gripper bars, in which event the microprocessor may be programmed to present the sheet, e.g. the leading edge thereof, to the gripper bars at the correct instant but at zero speed.

We have found that the use of a servo-drive, as in the embodiment of Figure 4, affords the potential for significantly greater flexibility in the range of sheet or board sizes that can be handled by the sheet treatment machinery in that a given arrangement of tooling on the rolls 12 may be used for cutting, printing, creasing or scoring discrete blanks of sheet material which differ substantially in length and in particular blanks that may be longer than the circumference of the tool-carrying roll set. In the following description, for simplicity the tools will be referred to as slotting tools; however, they may equally be other types of tool such as sheet creasing tools.

Referring to Figure 5, the smaller circle depicts the actual circumference of the upper roll 12 which is shown with four sets of tooling A, B, C and D, e.g. slotting tools, disposed at different locations around its periphery. Upstream of the rolls 12, a feeder as described with reference to Figure 4 is provided. Only feed rollers 14 are illustrated for simplicity.

The tools A, B,C and D are illustrated as being equispaced around the circumference of roll 12 but this is purely by way of example and is not essential. The sheets S are fed to the nip N by the rollers 14 from right to left as arrowed and

pass through the nip N between the upper and lower rolls 12 (the lower roll 12 being unshown in Figure 5) where contact is made with the tools as the rolls rotate and the board progresses through the nip. It will be understood that the rollers 14 act as means for transmitting drive from the servomotor 21 (see Figure 4) to the sheets but, under conditions where under the control of the roll set 12 the sheet is travelling at a speed greater than the speed of rollers 14 at that instant, the latter freewheel while remaining in contact with the sheet being fed. Once the sheet being processed by the roll set 12 clears one or more of the rollers however, braking of the roller or rollers no longer in contact with the sheet occurs so that freewheeling is arrested substantially instantaneously.

The sheet in Figure 5 is intended to be processed by the rolls in such a way as to slot the sheet at locations A1, B1, C1 and D1 which are spaced apart by distances corresponding to the spacings between the tools A, B, C and D. The sheet may therefore progress through the nip at substantially the same speed as the peripheral speed of the rolls 12. As illustrated, the slot at location A1 has already been produced and that portion of the sheet has advanced beyond the nip N. The slot B1 is in the process of production. Slots at locations C1 and D1 have yet to be produced. The slots A1, B1, C1 and D1 demarcate successive panels 1, 2, 3 and 4 and typically are each 400 mm in length, i.e. corresponding to a circumferential separation of 400 mm between the tools carried by upper roll 12.

In accordance with one of the aspects of the present invention, the sheet drive located upstream of the nip N is arranged to sheet feed not only to the nip but also participates in sheet feed through the nip, the arrangement being such that that sheet feed through the nip is only effected by rolls 12 primarily when one of the tools engages the sheet; at other times, except for the trailing section of the sheet (as described further below), sheet feed through the nip is effected by the upstream

sheet drive. A feature of this aspect of the invention is the capability of transferring sheet drive between the servomotor 21 and the roll set 12 while the sheet is travelling through the nip. In this regard, in contrast with conventional roll sets which are provided with sheet traction sections for driving the sheet when not engaged with the tooling, an embodiment in accordance with this aspect of the invention need not, at least not for the major length of the sheet, incorporate such sheet traction sections in addition to the tooling.

For a given production run, the rolls 12 will normally rotate at constant peripheral speed with the consequence that each tool will, in the direction of sheet travel, have a well-defined linear velocity the instant it registers with the dead centre position of the nip N. In practice, each tool will initially engage with the sheet at a location slightly upstream of the nip N and finally disengage from the sheet at a location slightly downstream of the nip, the precise points of tool-sheet engagement and disengagement being dependent upon factors such as the radial extension of the tooling and the thickness of the sheet material. Except for the trailing section of the sheet, in the embodiment of Figure 5 the sheet is fed through the nip N by the servomotor 21 (via rollers 14) during those phases of the treatment cycle when the tooling is not engaged with the sheet. To achieve this, the microcontroller 50 is programmed to regulate the servomotor speed. Through monitoring of the positional information derived from the encoder 31 and the sensor 32 coupled with information relating to the configuration of treatment operations to be performed on the sheet by the tooling , the microcontroller 50 serves to co-ordinate operation of the servomotor 21 with the roll set 12 in such a way the equipment is capable of handling a wide range of sheet lengths including lengths which signficantly exceed the circumference of the tool-carrying roll.

Thus, in the case of the sheet undergoing slotting in Figure 5, the servomotor 21 will be effective to drive the sheet through the nip N in such a way that the slots B1, C1 and D1 are created at predetermined locations relative to the slot A1 by feeding the sheet through a distance equivalent to the distance between the tool-sheet disengagement and tool-sheet engagement.

Because sheet feed through the nip N is primarily under the control of the servo-drive rather than the rolls 12, it is possible to cater for different cutting regimes using a roll set 12 of given circumferential dimensions. For example, Figure 6 shows a longer sheet size which is intended to be slotted at locations A2, B2, C2 and D2. Purely by way of example, panels 1 and 3 of the sheet illustrated in Figure 6 may have the same dimension (in the feed direction) as panels 1 and 3 in Figure 5, e.g. 400 mm. However, panels 2 and 4 may be different, e.g. 1100 mm in length. The slotting configuration of the sheet in Figure 6 can be achieved using the same set of rolls 12 as used to produce the slotting configuration of Figure 5 by pre-programming the microprocessor with appropriate data relating to the Figure 6 configuration so that, during passage of those sheet lengths corresponding to panels 2 and 4 through the nip N, the sheet is accelerated by the servo-drive/rollers 14 to a speed significantly greater than the tangential speed of the rolls 12 thereby compensating for the fact that the spacing between the slotting tools is less than the length of sheet to be left untreated between successive tool operations thereon.

In effect, the upper roll 12 will at times be equivalent to a virtual roll, depicted diagrammatically in Figure 5 by the circle referenced 12V, of much greater diameter than the actual roll 12. One possible speed profile imparted to the sheet is indicated diagrammatically in Figure 6. Thus, curves 60 and 70 represent the increased speed profile for sheet feed as the panels 2 and 4 are fed through the

nip N while lines lines 80 and 90 represent those intervals during which sheet feed is substantially the same as the tangential speed of the rolls 12.

It will be appreciated that when one or more of the panels is required to be shorter than the circumferential spacing between successive tools, the microcontroller (having been primed with the relevant information relating to panel sizes) is programmed to control the servo-drive in such a way that the sheet speed profile during travel through the nip is adapted to compensate for the fact that the sheet is required to travel a shorter distance compared with the circumferential spacing between successive tools. The speed profile may for instance involve a dwell period in which the sheet is stationary.

In practice, irrespective of the lengths of the panel sections relative to the circumferential spacings of the tools, the speed profile for servo-driven feed of the sheet may be such that each time a tool approaches the sheet, the sheet speed is travelling at a speed greater than the roll speed but is progressively reduced to so that the sheet speed is marginally slower (typically by a factor of up to 5%, e.g. 2 to 3%) than roll speed immediately prior to transfer of drive from the servomotor to the rolls 12. This allows the freewheel action to come into play thereby compensating for any line speed differential between the servo-drive 21 and the rolls and substantially reducing or eliminating any tendency for the sheet material to scuff or scrub the polyurethane surface of the lower roll which would thereby necessitate frequent replacement of the polyurethane. The instant that drive transfer from the servomotor 21 to the rolls 12 occurs, the tooling will be travelling faster than the sheet. The rollers 14 are thus caused to freewheel and will, in effect, turn through a well-defined angular distance corresponding to the length of sheet fed while the sheet is being driven by the rolls 12. At this time, the microcontroller may be progrrammed to slow down the servomotor or even stop

it altogether. As the point of tool-sheet disenagement approaches, the microcontroller causes the servomotor speed to increase again so that, at the point of tool-sheet engagement, the servomotor speed is substantially matched with the roll speed to effect smooth transfer of sheet feed back to the servomotor. To compensate for any line speed differential at the time of tool-sheet disengagement, the microcontroller may control the servomotor speed so that it is slightly slower than the tool speed immediately prior to such disengagement thereby allowing the freewheel action to effect such compensation.

During the time that there is tool-sheet engagement, the rollers 14 will be freewheeling. The braking applied to the rollers 14 is designed prevent any tendency for over run to occur due to inertia at the time of transfer of drive back to the servomotor, which could otherwise result in the sheet getting out of registration with the tooling.

If the sensor 32 is arranged to detect only one datum position on the sheet (e.g. the leading edge or a predetermined point in a printed image), the braking action exerted on the freewheeling rollers 14 is particularly important to prevent misregistration between the sheet passing through the nip and the tooling. However, the sensor 32 may be arranged to detect a number of strategically located datum positions on the sheet and feed back the information to the microcontroller so that, if any misregistration develops, this can be compensated for by appropriate control of the servomotor 21. In this case, the braking action is of lesser significance but may nevertheless be of advantage in limiting the extent of any misregistration that might otherwise occur through inertia-created over run of the rollers 14 when in freewheeling mode.

After the final tool disengages the sheet during treatment of a particular sheet, sheet drive is transferred back to the servomotor. However, because there is necessarily a gap between the rollers 14 and the nip N, the rollers will not be capable of completing drive of the sheet through the nip. This may be catered for either by transfer of the sheet to a further drive downstream of the nip, i.e. to drive the trailing section of the sheet through the nip, or by providing the roll set with a strategically located traction section 66 (see Figure 5). Where a further drive is provided downstream for this purpose, it may comprise a bed of rollers generally similar to the bed 13 of rollers 14 provided upstream of the nip N. In this event, the further set of rollers may be driven in exact synchronism with the upstream set of rollers, e.g. by using the same servo-drive 21 to drive both sets of rollers.

It will be understood that, for a given roll set and tooling arrangement, wide variations in sheet slotting (or printing/creasing/scoring) configuration and sheet length may be catered for by appropriate programming of the microcontroller. Thus, in practice, once the microprocessor has been programmed for a number of predetermined slotting configurations, the process may be carried out simply by inputting, for a given run, the particular slotting configuration required and the required dimensions. Thus, a user entry input 52 (see Figure 4) may be provided for entry of the relevant data into the microcontroller 50. User input may be menu driven; for instance, there may be a dislay monitor on which the selected slotting configuration is displayed with an invitation for the user to key in dimensions for each panel section.

The precise points of drive transfer from the rolls 12 to the servomotor 21 and *vice versa* may not be accurately predictable in advance because of variations in sheet thickness, humidity conditions, radial tool dimensions and settings etc. In order to cater for this, the microcontroller may be programmed to accept user-entered adjustments to allow such variations to be compensated for. For example,

after the microcontroller has been set up for a particular run, the operator may check the slotted sheets produced and, in the event of any offset from the desired slotting locations, may key in an adjustment via the input 52 so that the microcontroller can modify the sheet drive appropriately to remove the offset. This may be an interative process in practice - i.e. a number of samples may be checked with corresponding modification of the offset keyed into the microcontroller until the offset has been reduced or eliminated.

During the course of a given production run, the roll speed will normally be substantially constant; however the drive to the rolls 12 may be a variable speed drive so that roll speed may be increased or reduced for different productions runs (or even in the course of a particular production run). This allows greater flexibility in the lengths of sheet that can be handled. For instance, in the case of sheet which is to be produced with very large untreated panel sections, it may be desirable to operate at a lower roll speed (or even zero roll speed) while the tooling is out of engagement with the sheet material so as to afford more time for feed of long sections of the sheet by the servo-controlled drive.

For the avoidance of doubt, as used herein, except where the context admits otherwise, references to the roll set speed, the speed of the rollers 14 and the speed of the servomotor are to be construed in terms of the speed of travel of the sheet.

Although the invention is described above with reference primarily to the treatment of blanks of sheet material, the possibility is not excluded of feeding a continuous web of material to the rolls 12 and controlling web passage through the nip in the manner described above. Thus, for example, the rolls 12 may include tooling for severing, e.g. by cross-cutting, the continuous web fed thereto into discrete sheets of length up to or exceeding the circumference of the tool-carrying

roll or rolls. In addition to the severing tool, the rolls 12 may be provided with one or more circumferentially spaced tools for performing other operations on the web.

In a modification applicable to the various embodiments illustrated in the drawings, the bed of rollers 14 may be replaced by a vacuum transfer-type conveyor belt assembly in which one or more endless belts are entrained around a pair of rollers driven by the servo-drive motor, with the sheet material being supported and advanced by the upper run(s) of the belt(s) and optionally drawn into engagement with the upper run(s) by a vacuum produced beneath the upper run(s). In this arrangement, the belt(s) may be arranged to freewheel when the line speed of the sheet material is greater than the speed of the servo-drive motor and brake means may also be included to prevent over run of the freewheeling action. The freewheel action may be provided for by a suitable clutch arrangement between the servo-drive motor and one or more of the rollers of the conveyor belt, the arrangement being such that the conveyor belt assembly functions in substantially the same fashion as described in relation to the rollers 14 in each of the illustrated embodiments.

Referring to Figure 7, the tool-carrying roll set 12 may be as described in relation to the other illustrated embodiments. Instead of being preceded by the bed of rollers 14, the roll set in this case is preceded by a conveyor belt assembly comprising endless belts 100 entrained around rollers 102 so that the upper runs 104 form part of the sheet material support surface upstream of the nip N. Rollers 102 at the forward end of the conveyor belt are driven by servo-drive motor 106 under the control of the microprocessor 108 which receives positional data from a shaft encoder associated with the roll set 12 for registration purposes.

Though not shown, there will be a gate associated with the forward end of the conveyor belt assembly for ensuring that the sheets are released one at a time for advance towards the nip. Also, a sensor may be provided for detecting a datum position on the sheet to facilitate correct registration with the roll set, the sensor being linked to the microprocessor 108 to allow any correction to be made via the servo-drive motor and the conveyor assembly. A vacuum is drawn through the upper run (as depicted by arrow V) to hold down the sheet on to the conveyor assembly.

Initially the sheet is driven by the conveyor assembly to the nip N where the drive through the nip is then handled in part by the tooling carried by the roll set and in part by the servo-drive and conveyor belt assembly. As in the embodiment of Figure 5, the freewheeling action together with appropriate control, by the microprocessor 108, of the servo-drive motor speed serves to compensate for any line speed differential between the servo-drive motor 106 and the roll set 12 during transfer of sheet drive between the two. Also the servo-drive motor 106 is controlled by the microprocessor 108 so as to regulate drive of the sheet (when not driven by the roll set) in accordance with the predetermined configurations to be cut, creased, printed etc. by the roll set.

It will be appreciated that it is not intended to limit the invention to the above embodiments example only, many variations, such as might readily occur to one skilled in the art, being possible, without departing from the scope thereof as defined by the appended claims.

## CLAIMS

1. Apparatus for processing sheet material comprising;

a set of rotatable rolls provided with one or more sheet-processing tools for engagement with the sheet material in the nip zone between the roll set;

a first drive for rotating the roll set;

a second drive upstream of the nip zone for effecting feed of the sheet material; and

means operable to co-ordinate operation of the second drive with rotation of the roll set in such a way that sheet feed through the nip zone is effected for part of the time by the roll set and for part of the time by the second drive, the second drive imparting feed to the sheet material through drive transmitting means which freewheel while in engagement with the roll driven sheet.

2. Apparatus for processing sheet material comprising;

a set of rotatable rolls provided with one or more sheet-processing tools for engagement with the sheet material in the nip zone between the roll set;

a first drive for rotating the roll set;

a second drive upstream of the nip zone for effecting feed of the sheet material; and

means operable to co-ordinate operation of the second drive with rotation of the roll set in such a way that sheet feed through the nip zone is effected for part of the time by the roll set and for part of the time by the second drive.

3. Apparatus as claimed in Claim 1 or 2 in which the feed of sheet material through the nip zone is effected by the roll set at least while there is tool-sheet engagement.

4. Apparatus as claimed in Claim 1, 2 or 3 in which feed of sheet material through the nip zone is effected by the second drive at least for part (preferably a major part) of the time that there is no tool-sheet engagement.

5. Apparatus as claimed in any one of Claims 1 to 4 in which the roll set is provided with two or more circumferentially spaced sheet-processing tools.

6. Apparatus as claimed in Claim 5 in which the roll set is provided with a traction section trailing one of the tools for imparting feed motion to the sheet material subsequent to disengagement between said one tool and the sheet.

7. Apparatus as claimed in any one of Claims 1 to 6 in which the second drive is a variable speed drive operable to vary the speed profile of sheet material feed through the nip zone.

8. Apparatus as claimed in Claim 1 or any one of Claims 3 to 7 when dependent on Claim 7 including means for braking or damping freewheeling of said drive transmitting means so that freewheeling is arrested substantially immediately upon disengagement of the sheet from the drive transmitting means.

9. Apparatus as claimed in Claim 1 or 8 in which the drive transmitting means comprises rollers which engage the sheet material.

10. Apparatus as claimed in Claim 1 or 8 in which the drive transmitting means includes one or more endless conveyor belts which engage the sheet material.

11. Apparatus as claimed in any one of Claims 1, 8, 9 and 10 in which, during roll driven sheet material feed, the second drive is arrested or operates at a reduced drive speed compared with the roll drive speed.

12. Apparatus as claimed in any one of Claims 1 and 8 to 10 in which, during roll driven sheet material feed, the second drive is arrested or operates at a reduced drive speed compared with the roll drive speed and in which said drive transmitting means operates automatically in freewheel mode when engaged with sheet material being fed at a speed exceeding that of the second drive.

13. Apparatus as claimed in any one of Claims 1 to 12 in which, immediately prior to transfer of sheet material feed from the second drive to the roll set or *vice versa*, the second drive is programmed to run at a speed which is reduced compared with the roll speed.

14. Apparatus as claimed in any one of Claims 1 to 12 in which, during the interval leading up to transfer of sheet material feed from the second drive to the roll set or *vice versa*, the second drive operates in a mode in which its speed exceeds the roll speed and is then adjusted to a lower speed.

15. Apparatus as claimed in Claim 14 in which said lower speed is less than the roll speed.

16. Apparatus as claimed in any one of Claims 1 to 15 in which the co-ordinating means is programmable in dependence upon the configuration of tool operations to be performed on the sheet.

17. Apparatus as claimed in any one of Claims 1 to 16 in which the sheet material is fed to the roll set as discrete blanks.

18. Apparatus as claimed in any one of Claims 1 to 16 in which the sheet material is fed to the roll set as a continuous web of material.

19. Apparatus for feeding sheet material sequentially on demand to take up mechanism of sheet processing machinery, said apparatus comprising a feed table having a gate and upon which the sheets may be stacked against the gate which allows only the lowermost sheet to pass therebeneath, a bed of rollers within the surface of the table which may be rotatably driven to advance the lowermost sheet beneath the gate to the take-up mechanism, means to allow the rollers to free-wheel once the lowermost sheet is being advanced thereover by said take-up mechanism, and means for restraining freewheeling roller feed of the next lowermost sheet after the sheet being fed has passed under the gate.

20. Apparatus for feeding sheet material sequentially on demand to take up mechanism of sheet processing machinery, said apparatus comprising a feed table having a gate and upon which the sheets may be stacked against the gate which allows only the lowermost sheet to pass therebeneath, a bed of rollers within the surface of the table which may be rotatably driven to advance the lowermost sheet beneath the gate to the take-up mechanism, means to allow the rollers to free-wheel once the lowermost sheet is being advanced thereover by said take-up mechanism, and means for restraining freewheeling roller feed of the next lowermost sheet after the sheet being fed has cleared the rollers.

21. Apparatus for feeding sheet material sequentially on demand to take up mechanism of sheet processing machinery, said apparatus comprising a feed

surface having a gate and upon which the sheets may be stacked against the gate which allows only the lowermost sheet to pass therebeneath, conveyor means associated with the feed surface for advancing the lowermost sheet beneath the gate to the take-up mechanism, means to allow the conveyor means to free-wheel once the lowermost sheet is being advanced thereover by said take-up mechanism, and means for restraining freewheeling feed of the next lowermost sheet after the sheet being fed has cleared the conveyor means.

22. Apparatus as claimed in Claim 21 in which the conveyor means comprises roller means which directly engage with the lowermost sheet.

23. Apparatus as claimed in Claim 21 in which the conveyor means comprises roller means which contact the lowermost sheet indirectly through one or more conveyor belts entrained around the roller means.

24. Apparatus as claimed in any one of Claims 19 to 23 in which the restraining means comprises brake means acting on the rollers or conveyor means.

25. Apparatus as claimed in any one of Claims 19 to 23 in which the restraining means comprises vacuum suction means located upstream of the rollers or conveyor means to hold the next lowermost sheet against the action of the freewheeling rollers after the sheet being fed has passed under the gate.

26. Apparatus according to any one of Claims 19 to 25 in which the take-up mechanism comprises a tool-carrying roll set.

27. Apparatus according to any one of Claims 19 to 26 in which the rollers or conveyor means are fitted with sprag clutches and advance the sheet being fed at

substantially the same speed as, or a slower speed than that of, the take-up mechanism.

28. Apparatus according to any one of Claims 19 to 28 in which the rollers or conveyor means are driven by a servo electric motor which alternately drives the rollers or conveyor means forwardly and stops, the timing of the motor being controlled by the processing machinery.

29. Apparatus according to any one of Claims 19 to 28 wherein vacuum suction is applied from beneath the rollers or conveyor means to pull the lowermost sheet downwardly against the rollers.

30. Apparatus according to Claim 19 or 20 wherein the rollers are rotatably interconnected by timing drive belt means, one of which rollers is driven by a further timing drive belt.

31. Apparatus according to Claim 30 wherein said further drive belt is toothed.

32. Apparatus for feeding sheet material sequentially on demand to take-up mechanism of sheet processing machinery, said apparatus comprising a feed table having a gate and upon which sheets may be stacked against the gate which allows only the lowermost sheet to pass therebeneath, drive transmitting means driven by a servo-motor to advance the lowermost sheet beneath the gate to the take-up mechanism, a sensing means between the gate and the take-up mechanism to detect the passage of a datum position of the sheet, a microprocessor which receives data indicating the position of the take-up mechanism and from the sensing means and programmed to control the servo-motor to ensure that the sheet presents itself to the take-up mechanism at the correct instant.

33. Apparatus for feeding sheet material sequentially on demand to take-up mechanism of sheet processing machinery, said apparatus comprising a servo-drive motor, means for transmitting drive from the servo-drive motor to the sheet material to advance the sheet material to the take-up mechanism, sensing means for detecting the passage of a datum position of the sheet material as the latter advances towards the take-up mechanism, and a microprocessor which receives data indicating the position of the take-up mechanism and from the sensing means and programmed to control the servo-drive motor to secure registration between the sheet material and the take-up mechanism, the drive transmitting means being operable automatically in a freewheel mode while in engagement with sheet material travelling at a speed greater than the speed of the servo-drive motor.

34. Apparatus according to claim 32 or 33 wherein the microprocessor is programmed to ensure that the leading edge of the sheet presents itself to the take-up mechanism at a desired speed.

35. Apparatus according to claim 34wherein the desired speed is slightly less than the speed at which the take-up mechanism forwards the sheet.

36. Apparatus according to claim 34wherein the desired speed is zero.

37. Apparatus according to any one of Claims 32 to 36 wherein the take-up mechanism comprises a pair of take-up rolls.

38. Apparatus according to any one of Claims 32 to 36 wherein the take-up mechanism comprises gripper bars.

39. Apparatus according to any one of Claims 1, 8 to 10 and 32 to 38 wherein the means driven by the second drive or the servo-motor comprises a bed of rollers within the surface of the table which are rotatably driven to advance the lowermost sheet beneath the gate to the take-up mechanism when forward drive to the rollers is arrested and means to allow the rollers to free-wheel once the lowermost sheet is being advanced thereover by the roll set or take-up mechanism.

40. A method of treating sheet material by passage through the nip between a set of rotatable rolls provided with a least one sheet treatment tool, comprising: driving the sheet material through the nip for part of the time by means of the rolls and for part of the time by a separate servo-controlled drive which acts on the sheet material at a location upstream of the nip, the servo-controlled drive being transmitted to the sheet through roller means or conveyor belt means capable of freewheeling while in contact with the roll set-driven sheet material.

41. A method of treating sheet material by passage through the nip between a set of rotatable rolls provided with a least one sheet treatment tool, comprising: driving the sheet material through the nip for part of the time by means of the rolls and for part of the time by a separate servo-controlled drive which acts on the sheet material at a location upstream of the nip.

42. A method as claimed in Claim 40 or 41 including supplying the sheet material to the nip in the form of discrete sheets.

43. A method as claimed in Claim 40 or 41 including supplying the sheet material to the nip in the form of a continuous web.

44. A method as claimed in Claim 43 in which the continuous web is severed into discrete sheets by the rolls.

45. A method as claimed in Claim 42 or 44 in which the length of the discrete sheets exceeds the circumference of the tool-carrying roll.

46. A method as claimed in any one of Claims 40 to 45 in which, between successive tool-sheet operations on a given sheet or section of sheet material, the servo-controlled drive feeds a section of sheet through the nip of a length which differs from the circumferential spacing on the roll between the tool(s) effecting such operations.

47. A method as claimed in Claim 40 or any one of Claims 42 to 46 when dependent on Claim 40 including applying a braking force to the freewheeling roller means or conveyor belt means to prevent over run thereof.

48. A method as claimed in any one of Claims 40 to 47 including sensing the sheet position by detection of a datum position on the sheet and controlling sheet feed by the servo-controlled drive to secure at least initial registration between the sheet and the roll set tooling.

49. A method as claimed in any one of Claims 40 to 47 including sensing the sheet position by detection of a plurality of lengthwise spaced datum positions on the sheet and controlling sheet feed by the servo-controlled drive to secure and maintain registration between the sheet and the roll set tooling.

50. A method as claimed in any one of Claims 40 to 49 including feeding a terminal trailing section of the sheet through the nip by means of a non-tool-carrying section of the roll set.

51. Sheet treated by the method claimed in any one of Claims 40 to 50.

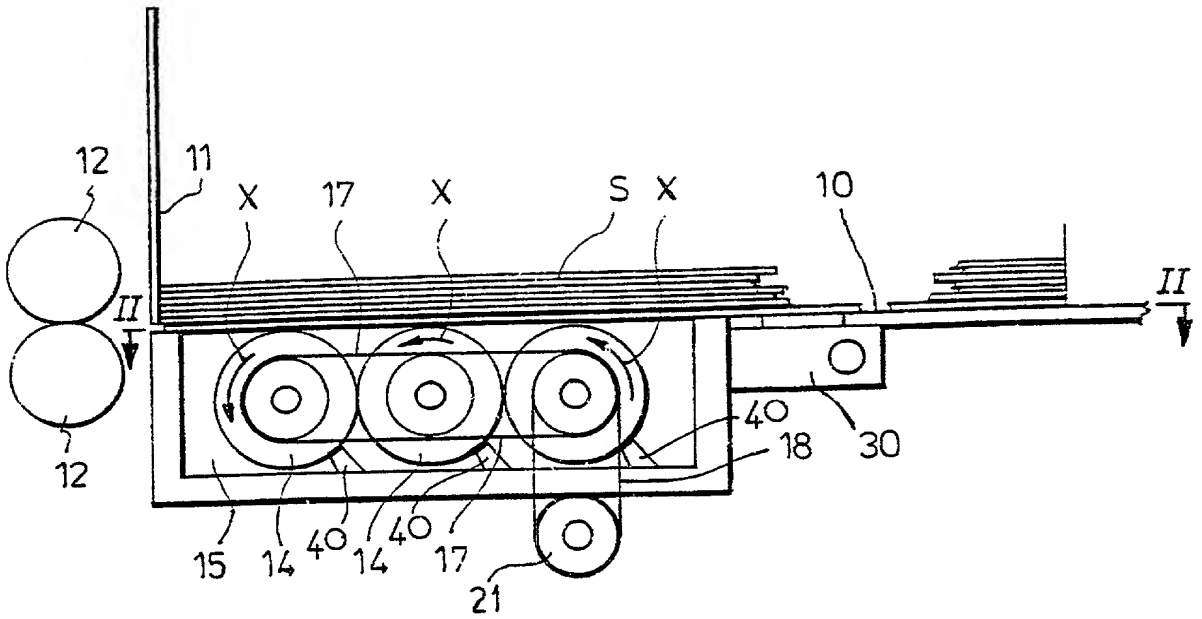
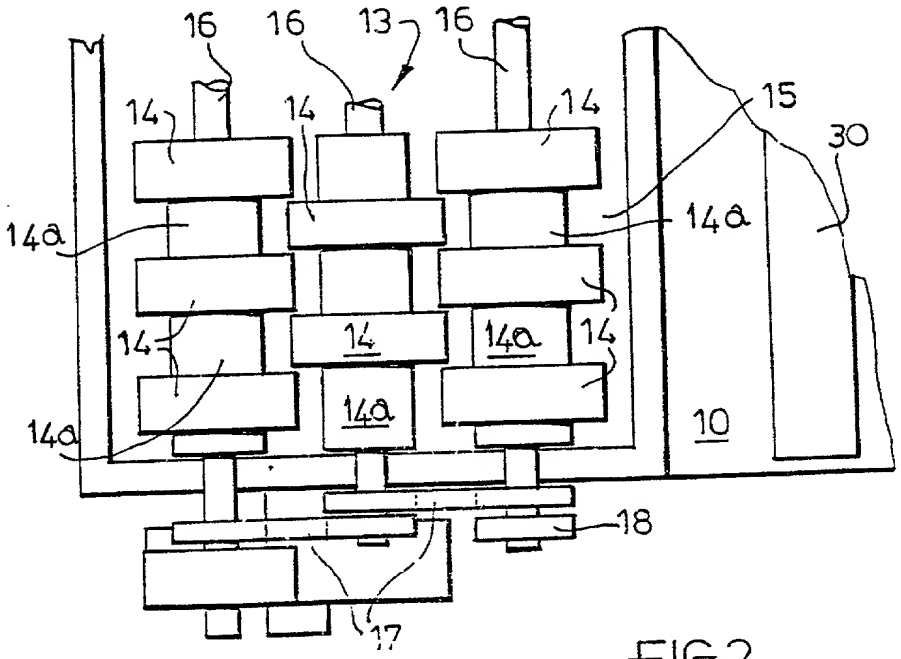

12
11
X
17
X
S
X
10
II
II
12
40
18
30
15
14
40
14
40
17
21

FIG.1


16
16
13
16
14
14
14
15
30
14a
14a
14
14
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14a
14a
14a
10
18
17

FIG.2

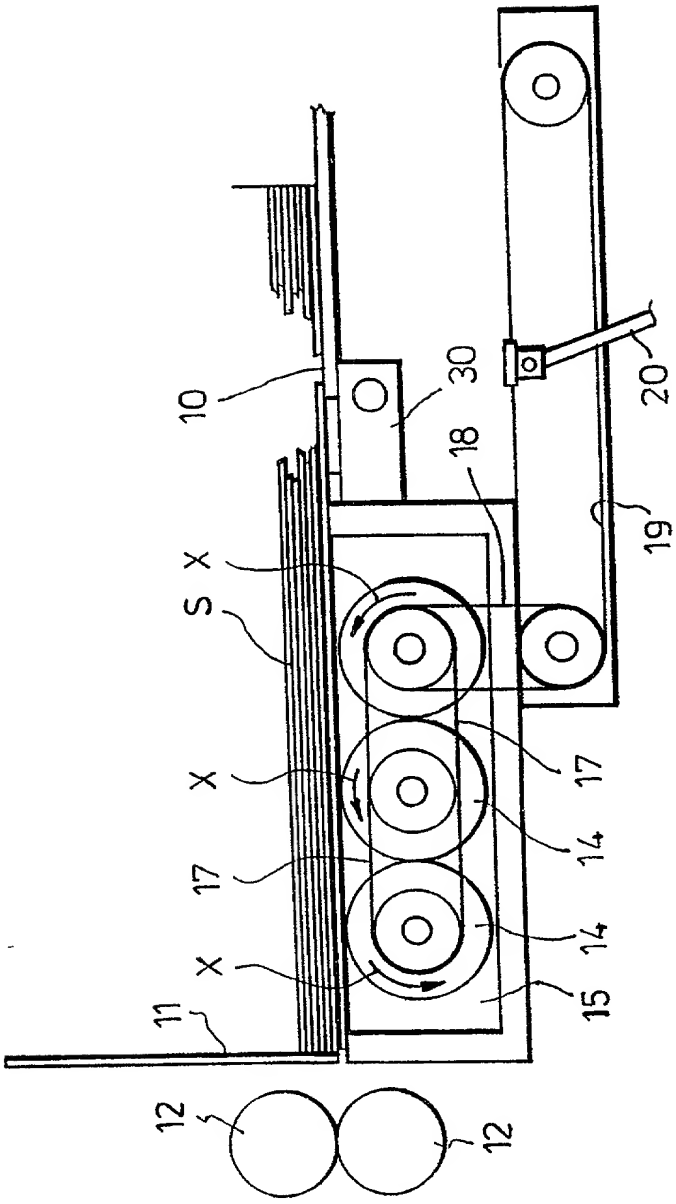


FIG.3

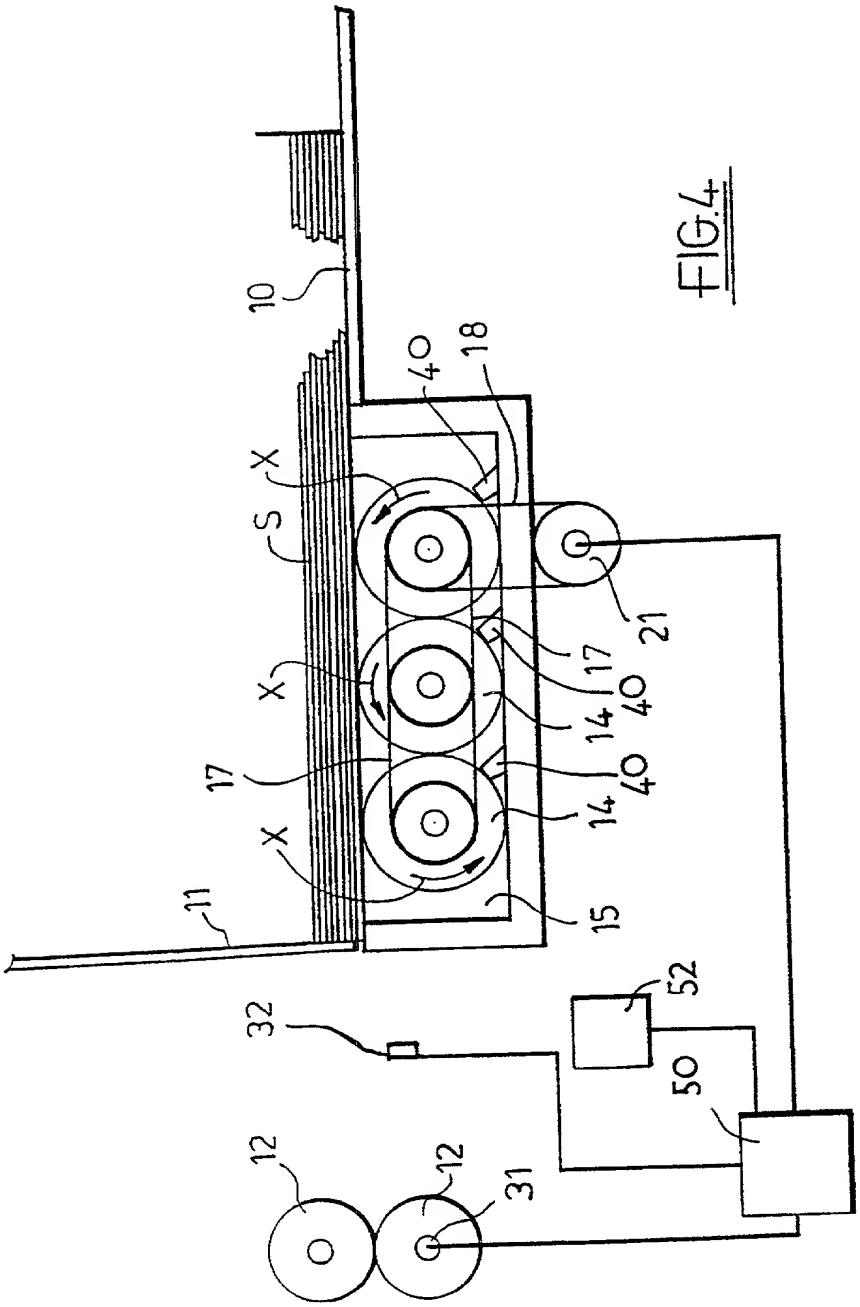


FIG.4

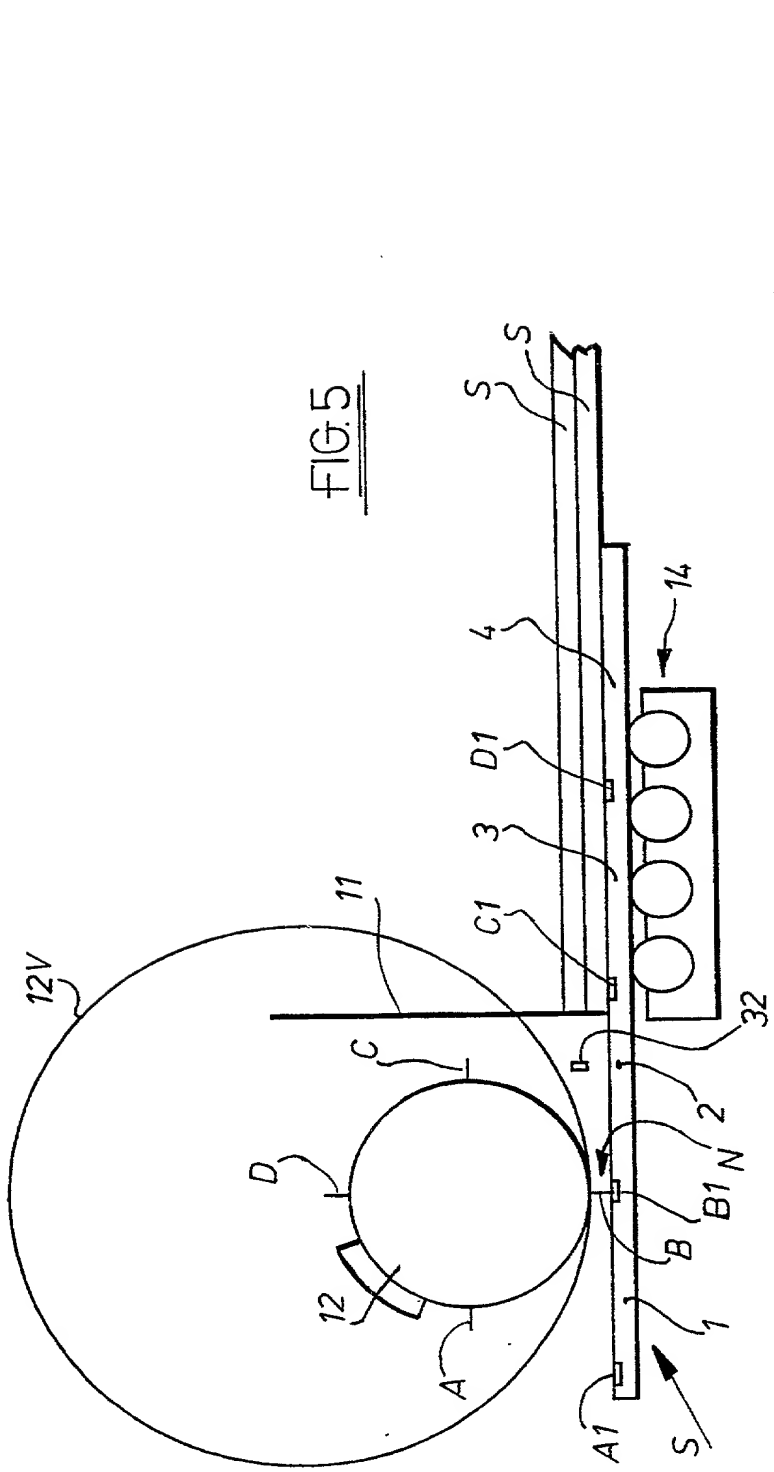
12V
11
C
D
12
A
A1
S
1
B
B1
N
2
32
C1
3
D1
4
S
S
14

FIG.5

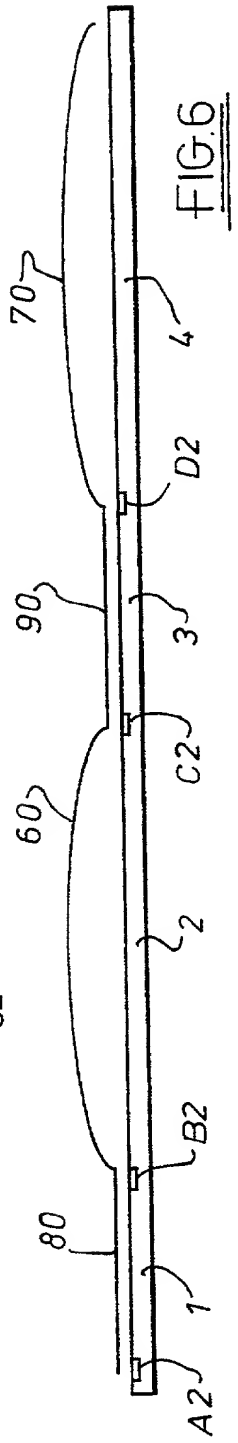
70
4
D2
90
3
C2
60
2
B2
80
1
A2

FIG.6

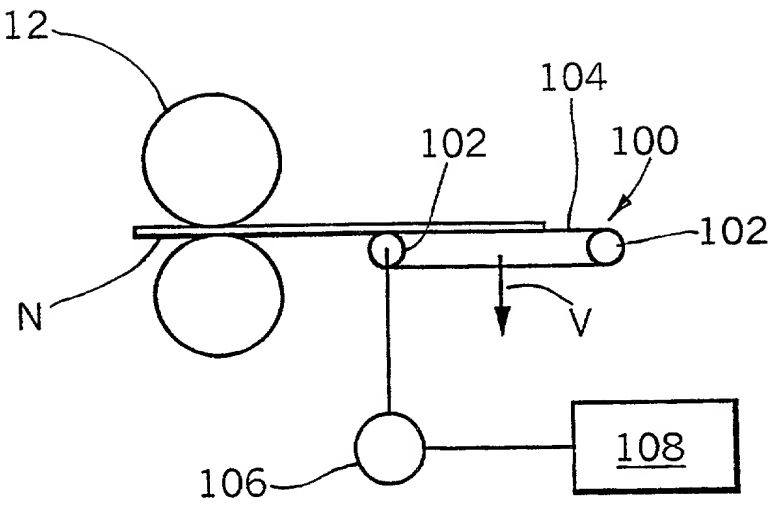


FIG.7

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | | |
|---|---|---|
| IN RE APPLICATION OF: John Anthony Sullivan | § | DOCKET NO.: 2165JB.45631 |
| SERIAL NO.: Unknown | § | GROUP ART NO.: Unknown |
| FILED: Herewith | § | EXAMINER: Unknown |
| TITLE: Sheet Material Processing | § | |

DECLARATION

As below named inventor, I declare that:

My residence, post office address and citizenship are as stated below, next to my name,

I believe I am the original, first inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled **Sheet Material Processing**, the specification of which

__ is attached hereto

__X__ was filed on 3/24/2000 as PCT Application No. PCT/GB00/01129 and for which a preliminary amendment was filed in the USPTO on herewith.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 (a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

| (Number) | (Country) | (Day, Month, Year, Filed) | Priority Claimed |
|---|---|---|---|
| PCT/GB99/01010 | PCT | 31/03/99 | Yes |
| PCT/GB99/02040 | PCT | 29/06/99 | Yes |
| 9916159.8 | GB | 10/07/99 | Yes |

I hereby claim the benefit under Title 35, United States Code §119(e) of any United States provisional application(s) listed below.

---

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s), or § 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

PCT Parent

| (PCT Filing Date) | (PCT Application No.) |
|---|---|
| 24 March 2000 | PCT/GB00/01129 |

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or

first inventor: John Anthony Sullivan

Inventor's Signature: _____ Date: 30 AUGUST, 2001

Residence: GB

Citizenship: British

Post Office Address: Pinfold, Church Lane, Woodford, Stockport

Cheshire SK7 1RQ, GB GBN

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | | |
|---|---|---|
| IN RE APPLICATION OF: John Anthony Sullivan | § | |
| | § | DOCKET NO.: 2165JB.45631 |
| FILED: Herewith | § | |
| | § | GROUP ART NO.: Unknown |
| SERIAL NO.: Unknown | § | |
| TITLE: Sheet Material Processing | § | EXAMINER: Unknown |

**POWER OF ATTORNEY**

The Honorable Commissioner
of Patents and Trademarks
Washington, D.C. 20231

Sir:

As a named inventor, I hereby revoke all previous powers of attorney and appoint the following to conduct the prosecution of this application/maintenance of the patent and transact all business in the Patent and Trademark Office connected therewith:

15

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Keith Taber, Reg. No. 46,114;
Darryl M. Tyus, Reg. No. 40,853, and

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Date : 30 AUGUST 2001

John Anthony SULLIVAN